

# Mammals of medium and large size in Cerrado remnants in southeastern Brazil

## Mamíferos de médio e grande porte em remanescentes de Cerrado de Minas Gerais, Brasil

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Academic editor: *A.M. Leal-Zanchet* | Received 19 November 2018 | Accepted 31 March 2019 | Published 15 July 2019

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Citation: Laurindo RS, Toledo FRN, Teixeira EM (2019) Mammals of medium and large size in Cerrado remnants in southeastern Brazil. *Neotropical Biology and Conservation* 14(2): 195–206. <https://doi.org/10.3897/neotropical.14.e37653>

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### Abstract

The Cerrado is the second largest biome in Brazil and considered a global biodiversity hotspot due to its high species richness, elevated amount of endemisms, and several anthropogenic threats. The Cerrado has more than 250 species of mammals, and about 15% are endemic. However, fragmentation and the consequent loss of native habitat threaten the maintenance of mammalian populations. In this context we carried out an inventory of medium- and large-sized mammals in Cerrado remnants in Matutina, Minas Gerais, southeastern Brazil. Sampling was performed in four remnants of Cerrado and adjacent agricultural matrices for 18 days and 16 nights in March and July 2015 with camera traps, diurnal and nocturnal censuses, and by searching for tracks and other indirect evidence. We recorded 19 species of mammals, including top predators and species vulnerable to extinction. The original vegetation cover in the study area has become severely reduced and fragmented due to agricultural expansion. However, the remnants still retain considerable diversity of medium- and large-sized mammals, making them important for the maintenance of biological diversity.

### Resumo

O Cerrado é o segundo maior bioma brasileiro, sendo considerado um hotspot de biodiversidade global devido à sua alta riqueza de espécies, elevada quantidade de endemismos e várias ameaças

antrópicas. Há registro de mais de 250 espécies de mamíferos para o Cerrado, 15% delas endêmicas. Contudo, a fragmentação e a consequente perda de habitat nativo ameaçam a manutenção de suas populações de mamíferos. Nesse contexto, realizamos um inventário de mamíferos de médio e de grande porte em remanescentes de Cerrado em Matutina, Minas Gerais, Brasil. Nos meses de março e julho de 2015 foram realizados 18 dias e 16 noites de amostragem através de armadilhas fotográficas, censo diurno e noturno, e busca por vestígios. Registramos 19 espécies de mamíferos, incluindo predadores de topo de cadeia e espécies vulneráveis à extinção. A região estudada sofreu uma severa redução e fragmentação da cobertura vegetal original devido à expansão da agropecuária. Contudo, os remanescentes ainda conservam uma considerável parcela da diversidade de mamíferos de médio e grande porte, sendo importantes para a manutenção da diversidade biológica.

### **Keywords**

agricultural mosaic, camera trap, Brazilian savanna, mammal fauna

### **Palavras-chave**

armadilha fotográfica, mastofauna, mosaico agrícola, savana brasileira

## **Introduction**

The Cerrado (Brazilian savanna) is the second largest morphoclimatic domain in South America and comprises a mosaic of savanna phytophysionomies that cover an area of more than two million square kilometers, which is equivalent to 23% of the extension of the Brazilian territory (Silva et al. 2006). Due to the expansion of agriculture and severe reduction and fragmentation of native habitats, the Cerrado is considered one of the most endangered tropical savannas in the world (Silva and Bates 2002). Estimates made at the beginning of the 21<sup>st</sup> century indicated that approximately 55% of the original vegetation cover was destroyed by anthropic activities, mainly to grow soybeans, corn, sugar cane and eucalyptus and to create pastures (Klink and Machado 2005).

Indeed, the Cerrado has high species richness and high rates of endemism, which makes it a global biodiversity hotspot (Myers et al. 2000; Klink and Machado 2005). More than 250 species of mammals have been recorded in this domain and about 15% of them are endemic (Paglia et al. 2012, Gutiérrez and Marinho-Filho 2017). However, the fragmentation and consequent loss of native habitat threatens the maintenance of mammal populations, especially the larger species (Silva and Diniz-Filho 2008). Additional studies are needed to understand the magnitude of the damage caused to biodiversity due to the destruction of the Cerrado. Based on this, species surveys are at the forefront of the biological sciences, since they reduce the Wallacean shortfall and allow the construction of conservation plans (Whittaker et al. 2005; Oliveira et al. 2009a).

Many inventories of large- and medium-sized mammals have been conducted in conservation units (CUs) (Rodrigues et al. 2002; Câmara and Oliveira 2012; Leite et al. 2016; Cabral et al. 2017); however, only 8.34% of the Cerrado is part of the system of protected areas (Françoso et al. 2015). Most of the mammal populations are

outside of CUs and are more susceptible to anthropic impacts. Previous studies have demonstrated that some species of large- and medium-sized mammals may be able to persist in fragmented landscapes in the Cerrado by using different agricultural matrices to move between patches of native vegetation. However, severe loss of native vegetation may be a crucial obstacle to the long-term survival of some species (Crooks et al. 2011).

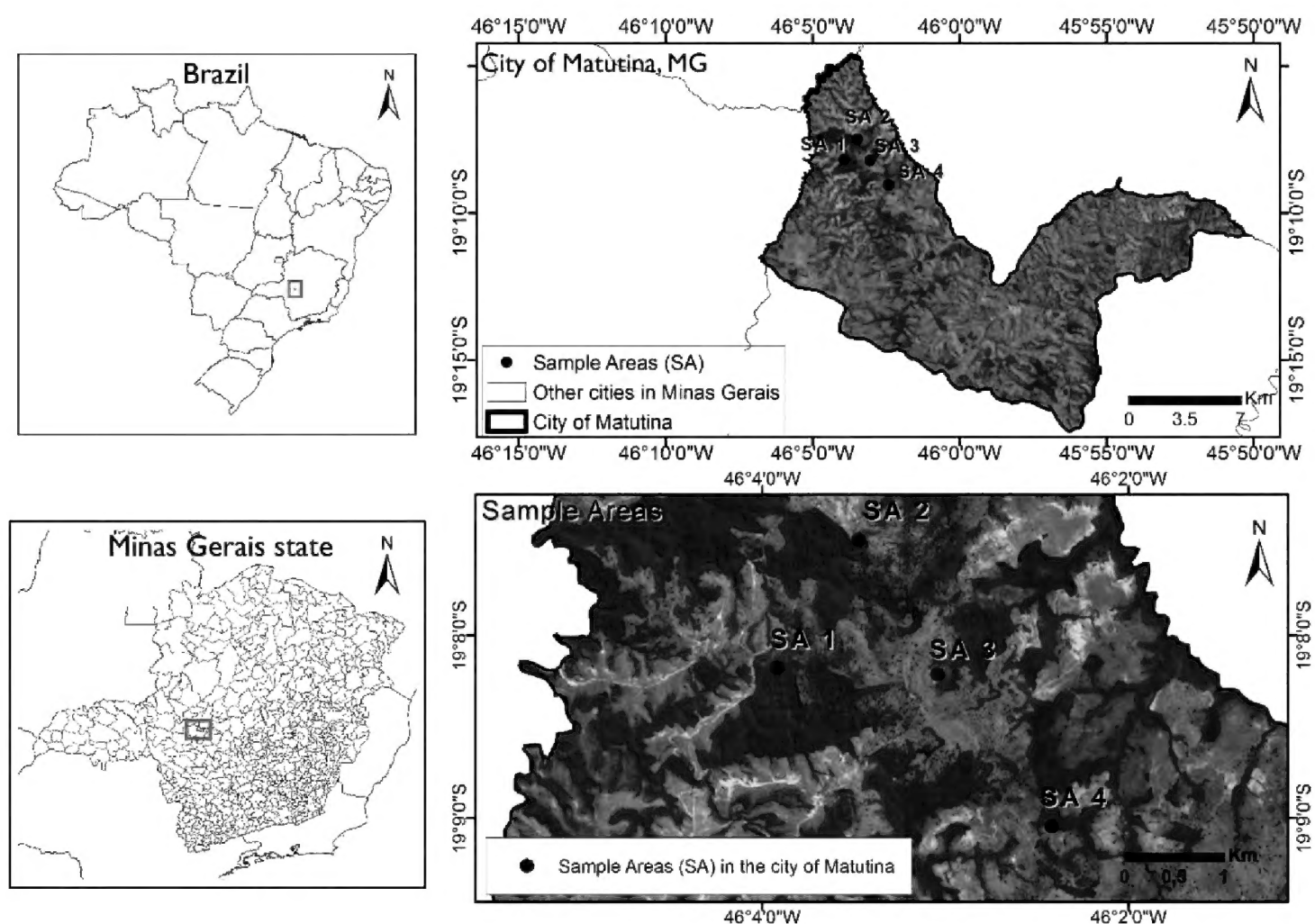
In this context, we present here the results of a survey of medium-sized and large mammals in Cerrado remnants immersed in an agricultural landscape in the Triângulo Mineiro. The Triângulo Mineiro and Alto Paranaíba are regions in the Cerrado domain, in the state of Minas Gerais, with scarce records of mammal species. In addition, these regions have large areas of pasture, sugarcane and soybean crops that have replaced significant areas of the Cerrado (Drumond et al. 2005).

## Material and methods

The study was conducted at Fazenda Ferreiros, in the municipality of Matutina, Minas Gerais, southeastern Brazil (19°08'S, 46°03'W, Fig. 1). The study area comprises fragments of seasonal forest, gallery forest along water courses and anthropic areas destined to be pasture. The climate is tropical savanna (subtype Aw), with a hot and rainy summer from October to March and dry winter from April to September (Reboita et al. 2015).

Sampling was carried out in four remnants of Cerrado and adjacent agricultural matrices for eight consecutive days in March and July 2015 (totaling 18 days and 16 nights sampling). The medium and large mammals were sampled using three methods. The first method was an active daytime search, where walks were taken in each Cerrado fragment on trails that were between 650 and 1,500 meters (depending on the fragment). A distance of 2,000 meters was also traversed in the matrix adjacent to the remnants of Cerrado. The active daytime search consisted of recording direct (observation) and indirect (footprints, feces, and burrows) signs. Each fragment was sampled for two days, one in the dry season and the other in the rainy season. The second method was a nocturnal census, carried out with a vehicle and an observer with a spotlight. This survey covered a total of 7,000 meters per night. The census was carried out on roads that pass close to the forest fragments and also the agricultural matrices. The nocturnal censuses were performed on six nights, three in the dry season and three in the rainy season, totaling 42,000 meters. Finally, two camera traps (Bushnell® Trophy Cam) were installed in each of the four fragments. One trap was located inside the fragment and another one was on the border, directed to the adjacent matrix; the average distance between the two cameras was 403m (minimum = 287m, maximum = 518m). Each photographic trap remained active for 24 hours for six nights and eight consecutive days, resulting in a total sampling effort of 48 cameras/night.

We used field guides to help the identification of traces found in the field (e.g., Becker and Dalponte 1999; Borges and Tomás 2005; Mamede and Alho 2008). The taxonomic nomenclature used was standardized according to Paglia et al. (2012).



**Figure 1.** Study sites in remnants of Cerrado in southern Minas Gerais, southeastern Brazil. Points represent the sampled locations.

We constructed a species accumulation curve with 1,000 iterations. To estimate the expected species richness, we used the first-order Jackknife (Jackknife-1), a non-parametric estimator in the program EstimateS version 8.0. To elaborate the curve and to estimate the species richness, we evaluated the presence and absence data of the species in the sampled sites.. Exotic species were excluded from the statistical analyses.

## Results

We recorded 19 species of medium-sized and large mammals, including 17 native species and two exotic species, distributed in six orders and 12 families (Table 1, Fig. 2). Carnivora was the most representative order with 10 species, corresponding to 52% of the total number of species, followed by Primates with three species (17.6%).

The search for indirect traces (mainly footprints) was the most efficient methodology; ten species were recorded using this method. Camera traps and direct observations during the censuses recorded five species each. *Myrmecophaga tridactyla* and *Dasyprocta azarae* were recorded only by camera trap, *Callithrix penicillata* and *Conepatus semistriatus* were directly observed during the day and night censuses, and the other eight species were recorded from indirect traces (Table 1).

**Table 1.** List of large- and medium-sized mammals in an area of Cerrado in Matutina, Minas Gerais, Brazil. Record type: [1] camera trap, [2] footprint, [3] direct observation, [4] vocalization. Habitat: [1] forest fragment, [2] agricultural matrix (pasture). \*domestic species.

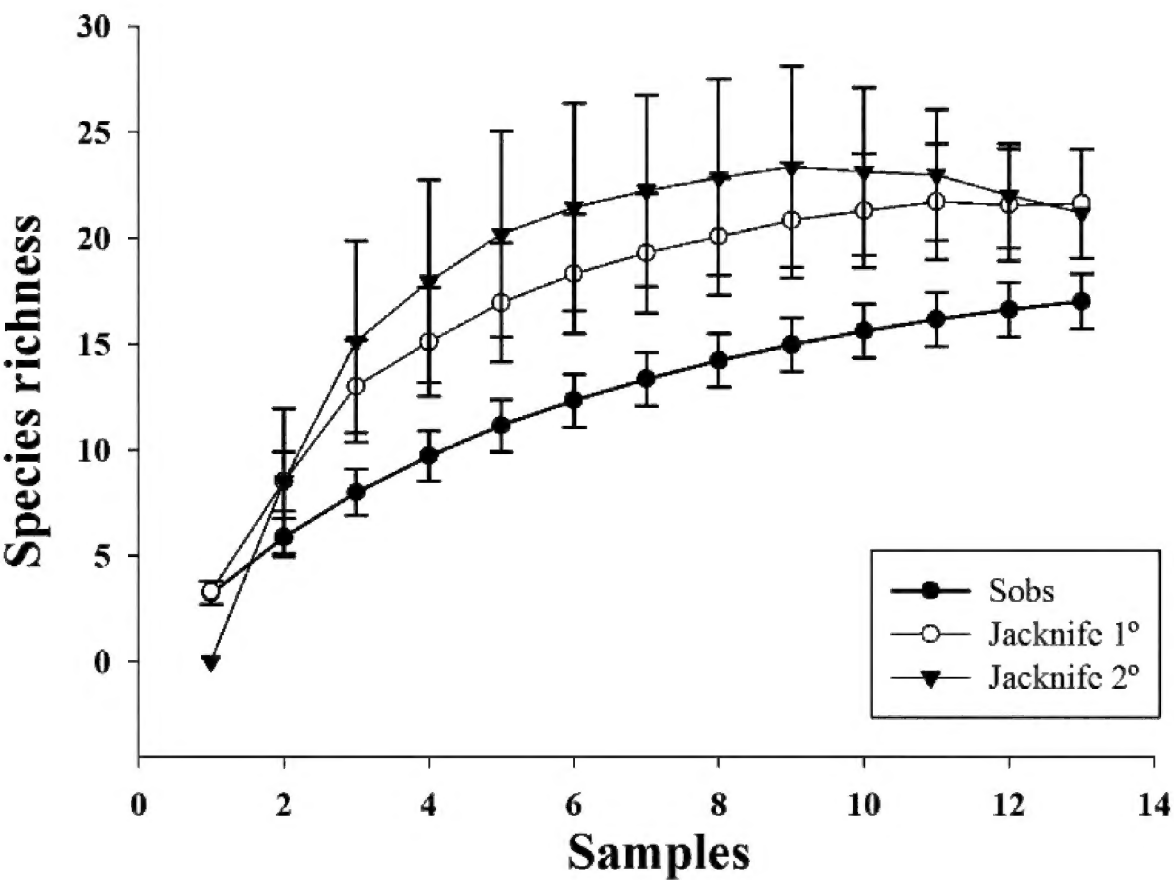
Taxon	Vernacular name	Record	Habitat
<b>Carnivora</b>			
<b>Canidae</b>			
<i>Canis familiaris</i> *	Domestic dog	[2][3]	[1][2]
<i>Cerdocyon thous</i>	Crab-eating Fox	[2]	[1] [2]
<b>Felidae</b>			
<i>Felis catus</i> *	Domestic cat	[3]	[2]
<i>Leopardus pardalis</i>	Ocelot	[1] [2]	[1] [2]
<i>Puma concolor</i>	Puma	[2]	[2]
<b>Mephitidae</b>			
<i>Conepatus semistriatus</i>	Striped Hog-nosed Skunk	[3]	[2]
<b>Mustelidae</b>			
<i>Eira barbara</i>	Tayra	[1] [2]	[1][2]
<i>Galictis cuja</i>	Lesser Grison	[2]	[1]
<i>Lontra longicaudis</i>	Neotropical Otter	[2]	[1]
<b>Procyonidae</b>			
<i>Nasua nasua</i>	South American Coati	[2]	[1] [2]
<i>Procyon cancrivorus</i>	Crab-eating Raccoon	[2]	[1]
<b>Cingulata</b>			
<b>Dasypodidae</b>			
<i>Dasypus novemcinctus</i>	Nine-banded Armadillo	[2]	[1][2]
<b>Lagomorpha</b>			
<b>Leporidae</b>			
<i>Sylvilagus brasiliensis</i>	Tapeti	[1][3]	[2]
<b>Pilosa</b>			
<b>Myrmecophagidae</b>			
<i>Myrmecophaga tridactyla</i>	Giant Anteater	[1]	[2]
<b>Primates</b>			
<b>Callitrichidae</b>			
<i>Callithrix penicillata</i>	Black-pencilled Marmoset	[3]	[1]
<b>Cebidae</b>			
<i>Sapajus libidinosus</i>	Bearded Capuchin	[3] [4]	[1]
<b>Pitheciidae</b>			
<i>Callicebus nigrifrons</i>	Black-fronted Titi Monkey	[3] [4]	[1]
<b>Rodentia</b>			
<b>Caviidae</b>			
<i>Hydrochoerus hydrochaeris</i>	Capybara	[2]	[1] [2]
<b>Dasyproctidae</b>			
<i>Dasyprocta azarae</i>	Azara's Agouti	[1]	[1]

The species accumulation curve indicates that the continuity of sampling should add new species to the list. The estimated richness of Jackknife-1, based on the sampling, was 24 species ( $\pm 2$ ), showing that the richness observed represented 70% of the total species expected for the site (Fig. 3).

Considering the type of environment, seven species were recorded only in forest fragments, four species were exclusive to agricultural matrices and six species were recorded in both environments (Table 1).



**Figure 2.** Records made from camera traps at Fazenda Ferreiros, Matutina, Minas Gerais, southeastern Brazil: (A) *Dasyprocta azarae*; (B) *Leopardus pardalis*; (C) *Myrmecophaga tridactyla*; (D) *Eira barbara*.



**Figure 3.** Species accumulation curve (solid line) and richness estimator (dashed line) for medium- and large-sized mammals at Fazenda Ferreiros, Matutina, Minas Gerais, southeastern Brazil.

## Discussion

Studies conducted both in conservation units (CUs) and outside protected areas have recorded high mammal richness in the Cerrado. Depending on the locality, richness has varied between 17 and 27 species in CUs (Oliveira et al. 2009b; Leite et al. 2016; Cabral et al. 2017) and between 15 and 25 species on private property (Cáceres et al. 2010; Lessa et al. 2012; Estrela et al. 2015). Thus, the richness of medium-sized and large mammals recorded in the present study agrees with other studies carried out in areas of Cerrado in Brazil (Rocha and Dalponte 2006).

The highest species richness for Carnivora, as recorded in the present study, was expected, since this order has the largest number of species of medium-sized and large mammals in the Cerrado (Paglia et al. 2012). The presence of domestic dogs and cats living in the interior and surrounding Cerrado remnants is a potential threat to local biodiversity (Paschoal et al. 2012). In addition to predation, feral dogs and cats can spread diseases in wild animals (Curi et al. 2010; Loss et al. 2013).

The occurrence of *Puma concolor* is notable. This species is a top predator that plays an important role in maintaining the trophic web, since it has an extensive range and needs large habitats to survive (Maehr et al. 2002). Similarly to other large mammals, *P. concolor* is negatively affected by fragmentation and loss of habitat (Morrison et al. 2007). The fragments in the study area are probably insufficient to maintain a population of large-sized carnivores, being just used as a corridor.

Two other notable species are *Leopardus pardalis* and *Myrmecophaga tridactyla*. *Leopardus pardalis* feeds on smaller rodents and marsupials, as well as larger prey, such as primates, armadillos and reptiles (Bianchi et al. 2010), helping the control of their population densities (Fonseca and Robinson 1990; Terborgh 2000). *Myrmecophaga tridactyla* is a species considered vulnerable to extinction at the national and international level (Miranda et al. 2014).

Despite the advance of agriculture and livestock farming in the region, the four remnants that we studied preserve an important portion of medium-sized and large mammals of the Cerrado biome. Studies show that some species of medium and large mammals can use landscapes formed by forest fragments and agricultural areas, and that they explore both native vegetation and agricultural matrices (Trolle et al. 2007, Lyra-Jorge et al. 2008, Bruna et al. 2010). However, the survival of these species over the long-term depends on the amount of available habitat, matrix type and size and connectivity of the fragments (Carvalho et al. 2009; Rocha et al. 2018). It is important to note that the absence of seed dispersers, such as *Tapirus terrestres* and *Tayassu pecari*, and the loss of large-sized frugivores can negatively affect the recruitment and survival of plant species, mainly those showing fruits with large seeds (Galetti et al. 2015).

Small fragments of native vegetation in landscapes modified by humans have been considered refuges for local fauna (Melo et al. 2013) and may harbor high species richness, including endangered species (Laurindo et al. 2017). In the present study, seven species were recorded exclusively from forest fragments, which could

be linked to the biological characteristics of the species (e.g., primates have an arboreal habit and are generally not found in pastures) or to habitat preference (e.g., *Lontra longicaudis* is a semiaquatic species and, in this study, was only recorded in the interior of riparian forests). Thus, it is important to develop conservation strategies to increase the functional connectivity of these areas, through the creation of corridors and stepping stones to connect these remnants, as well as strategies to manage the agricultural matrices.

The combination of different sampling methods (e.g., camera trap, census, and trail search) proved to be efficient at recording considerable species richness in a short sampling period, which reinforces the importance of combining different methodologies to increase sampling success. According to Carvalho et al. (2016), the most efficient methods to sample medium- and large-sized mammals involved searching for indirect (footprints, feces, and burrows) and direct (observation) records. Both in our study and in Carvalho et al. (2016), camera traps recorded approximately half of the species found by other methods, indicating the need for methodological variability for survey studies. Still, the use of camera traps is an important methodology for recording cryptic and less abundant species, which are rarely detected by other methods (Melo et al. 2012). In long-term studies, the use of camera traps is extremely advantageous, since it is the cheapest method, does not require the presence of a researcher during sampling and increases the chances of correctly identifying species compared to footprints (Carvalho et al. 2016). Mazza et al. (2018), in a study in RPPN Alto-Montana in southern Minas Gerais, continuously used camera traps for three years and recorded 21 native and four exotic species of medium- and large-sized mammals.

We also emphasize the importance of daytime censuses for direct observation, especially for primates, since both camera traps and searching for indirect traces may underestimate the presence of this group due to the arboreal habit. In this study, three primate species were recorded through visualization and vocalizations during the daytime censuses.

Although the medium- and large-sized mammal fauna represents one of the best studied groups in the world, for many species there are still knowledge gaps about distribution, habitat use and persistence after habitat destruction, especially in the Neotropics. Thus, faunal inventories are still of inestimable importance and may be the only information about the biodiversity of an area at risk of disappearing in a short time.

## Acknowledgments

We thank T.O.S. Lobato, D.T.S. Peixoto and J.R. Gonçalves for helping with fieldwork, Manna & Toledo Planejamento Ambiental Ltda. for the logistical support, and the Grupo Funchal e Fazenda Ferreiros for permission to use the data, to anonymous referees for the valuable suggestions. RSL thanks CAPES for the doctoral fellowship.

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